Vol.5, No.1 pp. 52-64
ISSN 1805-3602

Simulation and Ergonomic Study and fabrication Technology of Salt Man Footwear

Mahin Sohrabi, Nafiseh Yazdani*
Alzahra University, Tehran
*E-mail: nafiseyazdan_y65@yahoo.com

Received for publication: 29 January 2015.
Accepted for publication: 22 December 2015.

Abstract

The 'salt man footwear' is one of the most interesting cases of footwear in the world which, due to its physical properties and appearance, is estimated to belong to either the end of Parthian era or to the beginning of Sasanian era. The salt man is reported to have been a rider and, therefore, his footwear must have been of the 'riding boots' type. This specific type of footwear possesses certain features in accordance with the modern day technological rules. Therefore, the present study circles around this question that to what extent the sample under analysis corresponds with such rules. The research embarks on studying the characteristics of this footwear on the basis of a 'descriptive-exponential' research method. Evaluation and final judgment in order to achieve the technological pattern for simulation has been conducted through 'deductive reasoning, meaning that the historical footwear has been compared with the technological rules of manufacturing modern day footwear and simulation has been embarked on in a 'semi experimental' method. The results of the analysis reveal that the leather used in the salt man footwear is of split calf and cow leather type and had been tannered with 'lime and salt'. The threads used in this work are of the 'sheep intestine' type. The 'size of the historical footwear, according to the technical report of the Research Center for Conservation of Cultural Relics and through the accordance done with the modern day technical rules of sizing, has been determined to be 42. The ergonomic comparative study not only makes possible the fabrication of a similar prototype, but also reveals that the technology for the fabrication of such kinds of footwear had existed 1700 years ago in Iran.

Keywords: Salt man, footwear, leather, technology and ergonomics of footwear fabrication

Introduction

The 'salt man', together with a number of different objects including the leather footwear, was a specimen found in a salt mine located in the area which is today known as 'Zanjan City'. The Research Center for Conservation of Cultural Relics affiliated with the Cultural Heritage Organization has conducted some research on this man. It is stated in the research reports that the already-mentioned footwear is made of leather and has a sole size of 28 centimeters (Institute of Conservation and Restoration of Monuments, 1999).

Due to the fact that this natural substance has a three dimensional structure and is, therefore, biodegradable organic material (Sayed Sadr, 2009).

The specimen at hand is a very important piece of historical evidence and one of a kind remaining from 1700 years ago when it comes to the use of leather in footwear. The footwear can be seen in figure 1 (Shoe Industry Magazine (1995).

The present study, implementing some of the findings by the above-mentioned institute and focusing on the science of leather and the traditional technology of shoe industry, focuses its attention on the characteristics of this footwear and how it was fabricated. For this purpose, an

empirical study method (semi experimental) was implemented in order to fabricate a similar sample so as to introduce the stages of fabricating this work in a practical and objective way.

Figure 1: The salt man footwear, Iranian National Museum (author)

Body of Research

The geographical location: where and how slat man was discovered

The 'Chahrabad' salt mine, with an altitude of 1350 meters above sea level, is located 75 kilometers west of Zanjan and 1 kilometer south of the village 'Hamzelou'. A part of the salt mine which stands above Chahrabad River and 'Aji Chay' Stream possesses rich streaks of salt which have been subject to excavation from the past to the present (Research Center for Conservation of Cultural Relics, 1999).

Through the first year of mechanical operation[1] of the mine (winter 1993), while stripping the mine and extracting salt using bulldozers, the miners came across a human torso with long beard and hair (The Research Center for Conservation of Cultural Relics, 1998). Due to the fact that this torso had remained intact in a salt environment, it came to be known as the salt man. Subsequent to the end of the studies done on it in the laboratory of the Research Center for Conservation of Cultural Relics affiliated with the Cultural Heritage Organization[2],the torso was moved to the National Museum and had been kept there ever since.

[1] Until 1992 extracting salt from the Chahrabad salt mine was done traditionally using hand tools. In 1993, Zanjan Nasr company won the auction according to which the company acquired the right to operate the salt mine. Subsequent to that, mechanical utilization was started.

[2]The Research Center for Conservation of Cultural Relics affiliated with the Cultural Heritage Organization: the history of this research center dates back to 1972 when the reparation workshop in the center formerly known as the Iranian Archeology Center was established. Later on in 1991, the central laboratory of the Center for Conservation of Cultural Relics began work in the Cultural Heritage Organization with the purpose of executing research projects and supporting conservation plans.

After the news of this discovery was made public, a number of salvaging excavations were conducted, first supervised by Hooshang Sobooti and then by Ali Asghar Mirfattah. As a result of these excavations, a number of eye-catching objects were discovered from the mine (Research Center for Conservation of Cultural Relics, 1999).

The biography of salt man

The most significant finding from 1993 was the discovery of salt man's left foot which was in a boot-resembling footwear. The material of the footwear was leather (more like what is today known as split calf) and it had a height of 48 centimeters.

Upon the end of the excavations, the body and the discovered objects were taken to the conservation and reparation laboratory of the Center for Conservation of Cultural Relics for further observation and examination. The laboratory examinations included age determination, osteological studies using CT scans, blood type determination, DNA testing etc (the Research Center for Conservation of Cultural Relics, 1998). The full face of the salt man can be seen in figure 2 above (Research Center for Conservation of Cultural Relics, 1999).

Figure 2: The full face of salt man (author's personal album)

The objects discovered on the salt man

The objects discovered included: 'Breeches' which had a length of 35 centimeters from the waist down, 'two pieces of woolen rope' with a length of 35 centimeters, 'three pieces of leather rope' with a total length of 169 centimeters and an average width of 2 centimeters, and other metallic or non-metallic objects including three knives, a grindstone, a walnut, a sling, bone pieces, clay, and a bag for keeping a silver object which has an end like a small spoon and another like a pointed spiral which is commonly referred to as ear cleaner.

Figure 3: The objects found on the salt man (author's personal album)

These objects can be seen in figure 3 (Research Center for Conservation of Cultural Relics, 1999).

And the result of carbon 14 age determination on the bone and cloth pieces for salt man number one reveals that the salt man is likely to belong to either the end of the Parthian era or the beginning of the Sasanian era. Additionally, further examinations reveal that the discovered torso belongs to a middle-aged man who has suffered a heavy blow to the head and face before death.

It is to be noted that age determination examinations on this body are ongoing and provided that it is proved to be of 1700 years of age, it will be an undisputed piece of evidence and proof that Iran is the ancient owner of the footwear industry (Research Center for Conservation of Cultural Relics, 1998).

Features and characteristics of the salt man footwear

Figure 4: The left footwear of the salt man (author's personal album)

The leather from the footwear is soft and despite the fact that it has no water remaining within, it is not fragile or brittle. The facing and the underside are made from the same leather and they have been sewed together from inside.

Figure 5: The front part of the footwear (author's personal album)

As seen in Figure 4, the top collar part is folded and sewed. The vamp is completely separated from the toe box and they are sewed to each other with delicate stitches. Figures 5 views the front part of the footwear.

Form

As shown in Figure 6, in the form of this footwear, the shaft, though goes up to above the knee cap, maintains its shape and for the curve of the forefoot[3] and the tiptoe, the same technology which is common today in the shoe industry has been used. Figure 7 depicts the tiptoe of the footwear.

Figure 6: The shaft of the footwear (author's personal album)

Figure 7: Tiptoe of the footwear (author's personal album)

Ergonomics and anthropometrics of foot in footwear

Ergonomics and the issue of foot in footwear

The word 'ergonomics' is the combination of two Greek words namely 'ergon' meaning work and 'nomos' meaning rule (Foroozanfar, 2008). A short and to the point definition of ergonomics would be 'accurate and scientific knowledge of human body'. Considering ergonomic rules in footwear fabrication means that every footwear fabricated must be in harmony with the foot characteristics of the person wearing it so that it presents the highest level of efficiency and the lowest level of fatigue and other problems. In principle, ergonomics tries to achieve higher efficiency for both human and footwear (Pheasant, 1996).

[3]The curve of the forefoot is the knob on the metatarsal bone. In shoe fabrication, it is known as the vamp, and in the science of shoe modeling it is commonly referred to as the instep girth.

The importance of footwear structure and its effects on the body

Every anatomic change in the foot structure will affect footwear as well and, therefore, a glance at the footwear will help one realize the structural problems of a person's foot. Likewise, the pressure induced on one's foot from inappropriate footwear can lead to deformation in the bones and soft tissues of the foot.

Throughout the course of time footwear and its fabrication methods have changed in accordance with the requirements. Example can be sport footwear where the purpose is to serve the foot better in sport activities or medical footwear which has treatment purposes in cases of anatomic abnormalities, congenial deformation, uneven legs, and pain. In such cases, the appropriate footwear is designed and fabricated (Saffar, 2009:78).

Knowledge of foot and appropriate footwear

Footwear can both affect the foot and take effects from it. A quick glance at how the outsole of a given piece of footwear is worn can help one realize if the footwear is appropriate. For a normal foot, this attrition is insignificant and a normal amount of it occurs on the lateral areas of the front part of the outsole and in the outer areas of the heel cap. In normal conditions, the vamp will not fold or wrinkle; it will not curve from the inside or outside, and, from a rear view, no reversed curve would be observed in the vamp or heel cap areas.

Foot anthropometrics

1 - To tolerate body weight and to hold it in a balanced state

2 - To step and move the body forward

In the first state feet need resistance and in the second state they need flexibility. The point to be noted is that when feet are in the state of tolerating weight (standing condition), due to the extension in some parts, the size will be bigger. This expansion may be as big as half a size or one size. Therefore, feet must be measured in the standing and weight tolerating condition.

Human beings have always used footwear in order to shield their feet against heat, cold, and humidity and also to facilitate walking and standing through the course of history. Yet, they have been unaware of the effects footwear has on human anatomy. Nevertheless, today, with the breakthroughs in physical medicine and rehabilitation, people have grown to be aware of the importance of the human second heart (Saffar, 2009:89).

Foot parameters: definitions and measures

1 - Foot length: is the distance between the tip of the big toe to the middle of the bone curve behind the foot. It is measured using a measuring tape (or other specific devices designed for measuring footwear. This distance can also be measured using a Vernier caliper or a foot plan.

2 - Tiptoe: is the area around toe joints between the big toe and the small toe. This distance is also measured using a measuring tape.

3 - Forefoot curve or the instep: is the curve on the metatarsal bone up to around the flanches which is also referred to as the vamp.

4 - The heel or the little heel

5 - The big heel: is the area around the lowest part of the heel on the curve of the forefoot

6 - Ankle: is the joint of the calcaneus bone (heel) with the tibialis and fibula (shin)

7 - The height of the big toe

8 - The height of the small toe

9 - Shin length: in the distance between the plantar heel and the knee cap

10 - Half calf length: is the distance between the plantar heel and the curve of the calf (biceps) in the tip of the curve

11 - The area of shin and half calf

Human foot measurement is a science which studies different foot parameters, their measurements, and the relationships between them. Footwear tree model, which is traditionally a wooden shoe tree which gives the designer the size and primary form of the footwear, is designed basically based on foot sizes and measurements. Foot sizes and measurements are obtained by studying the anatomic points of the foot (Foroozanfar, 1999:90).

Salt man's foot anthropometrics and his footwear ergonomics

Salt man's left foot bone features

Left foot bones are soft and delicate and are of more thickness in the sole area. The sole tissue and the heel are completely preserved. All bones possess natural shape. The bending and retraction of the toes are possibly due to pain and high pressure. The visual adaptation of the tibia and fibula shows a false Figure of ankle fracture which is denied by the x-ray Figures (the Research Center for Conservation of Cultural Relics, 1999).

Salt man footwear anthropometrics

The whole structure of the salt man footwear is made from leather. The footwear has taken the form of the foot and in the front part the toe lump is easily noticed. Figure 8 depicts this lump. This is due to the soft splitcalf used in the footwear fabrication.

Figure 8: The toe lump on the footwear (author's personal album)

Salt man's left footwear structure

The footwear is made up of four parts:

1 - The shaft, which covers from above the knee cap to the big toe area on the forefoot, is of 48 centimeters of height to above the knee cap. The shaft can be seen in figure 9.

Figure 9: The shaft of the footwear above the knee (author's personal album)

2- The front part of the footwear (vamp) which starts from foot sole arc (metatarsus) and expands to the big toe taking a v shape towards the little toe and the other side. Figure 10 depicts the front part.

Figure 10: The front part of the footwear (author's personal album)

3- The U shaped part which starts from the foot sole arc, covers the upper heel and ends on the other side (figure 11).

Figure 11: Heel (ledge or box) of the footwear (author's personal album)

4 - The sole of the footwear which is uniformed with the upper parts and is of a length of 28 centimeters (figure 12).

Figure 12: The sole of the footwear (author's personal album)

Tables 1 and 2 below provide a comparative study and an image comparison of the footwear respectively.

Table 1: The comparative study of the footwear

The comparative study of the footwear	
Modern day prototype	Salt man
Material study	
In the reconstructed sample splitcalf material with the desired color proportion has been used as well. Although modern day tannery has been applied, the inward and outward characteristics of the original have been taken into consideration.	The leather used in the footwear is of the splitcalf type which is made from cow skin subjected to traditional and herbal tannery.
Modeling method	
Designing and modeling of footwear are considered to be of the most important stages in footwear fabrication. Nowadays, using foot ergonomics and modern technologies, shoe trees appropriate for different ethnicities are manufactured and shoe modeling is performed based on the measurements of the shoe tree. Nowadays modeling is carried out using both manually and using computers. In both cases modeling is carried out based on modern day science and with interceptive lines and angles leading to the desired harmony between the footwear and human foot. In the process of fabricating a modern day prototype of the salt man footwear a combination of the modern day and ancient methods has been implemented which is entirely innovative.(Nasiri Rad, K. (2012). Shoe Design and Modelling)	The design and modeling of salt man's footwear had been carried out manually using the visual skills by the shoe maker. The method used resembles tailoring in such a way that either measuring the calf and ankle areas and the forefoot was carried out using flexible tools such as measuring tape or something alike and the process of fabrication followed or the foot was placed on the selected material and, based on the foot parts, the proportions were cut out of the material and the parts were sewed together. These methods require great craftsmanship and skill and considered to be valuable in terms of experimental techniques.
Staggering	
The staggering of the modern day footwear has been carried out in exact accordance with the ancient techniques. Just like the original, the prototype has four parts made from splitcalf leather. All parts are sewed in the sew and reverse way with delicate blanket stitches and no lining or interface has been used in order for it to be like the original. In order to maintain the original form, no joinery has been carried out in hem (edge) sewing.	The salt man footwear for each foot has four parts (sole, toe box, heel, and shaft) which are all made from splitcalf leather. All parts are sewed from the inside (sew and reverse) without joiners. The shaft is a uniformed piece and is sewed only in the back in the sew and reverse way with very delicate blanket stitches. The footwear does not possess any lining and no interface is used.

Ergonomics	
In the reconstructed prototype, all ergonomic details recognized from the original have been applied. Additionally, by a comparative study of the modern ergonomic details and those of the salt man footwear, adjustments have been made.	As for the ergonomics of the salt man footwear, it can be said that, surprisingly, not only has modern day ergonomics been applied, but also the fabricator moves a step ahead of modern science. The sole of the footwear consist of only one uniformed part which gives the user comfort and flexibility while walking or running. The line connecting the toe box and the vamp is placed above the toe joints. Therefore, while walking, not only does it not cause any problems, but it also gives more comfort to the user. In the heel, a separate part has been used which is a reminder of the heel area and supports the heel and its motion. The shank is uniformed and continues from the upper end to above the knee cap and from the lower end to the instep. No sewing line exists in this area and this gives the footwear more comfort and flexibility especially in the ankle area. The most important point about the salt man footwear is that unlike modern day boots which stand up straight, it is fabricated like stockings which do not stand up straight. This means that the footwear is shaped by the foot and not the other way around and this leads to even more comfort for the user.

Table 2: Image comparison

Modern day prototype	Salt man footwear
	
Ledge (box)	
	

Sole	
	
Heel	
	
Toe cap	
	
Sewing type	
	
The quarter of the footwear	
	

Conclusion

In accordance with the study conducted on the salt man footwear, the following points can be mentioned:

1 - The leather used in the fabrication of the salt man foot wear is of the splitcalf type made from cow skin subjected to traditional and herbal tannery (using lime and salt). In the fabricated prototype, too, splitcalf leather has been used with color proportions similar to that of the original. The only difference is that the tannery applied is modern but the tannery method is chosen based on the visual characteristics of the original footwear.

2 - The design and modeling of the modern prototype, like that of the original, has been manual and with visual skills. The method used in the ancient footwear resembles tailoring in such a way that either measuring the calf and ankle areas and the forefoot was carried out using flexible tools such as measuring tape or something alike and the process of fabrication followed or the foot was placed on the selected material and, based on the foot parts, the proportions were cut out of the material and the parts were sewed together. These methods require great craftsmanship and skill and considered to be valuable in terms of experimental techniques. Designing and modeling of footwear are considered to be of the most important stages in footwear fabrication. Nowadays, using foot ergonomics and modern technologies, shoe trees appropriate for different ethnicities are manufactured and shoe modeling is performed based on the measurements of the shoe tree. Nowadays modeling is carried out using both manually and using computers. In both cases modeling is carried out based on modern day science and with interceptive lines and angles leading to the desired harmony between the footwear and human foot. In the process of fabricating a modern day prototype of the salt man footwear a combination of the modern day ancient methods has been implemented which is entirely innovative.

3 - The salt man footwear has four parts (sole, toe box, heel, and shank) which are all made from splitcalf leather. All parts are sewed from the inside (sew and reverse) without joiners. The shank is a uniformed piece and is sewed only in the back in the sew and reverse way with very delicate blanket stitches. The footwear does not possess any lining and no interface is used.

4 - The staggering of the modern day footwear has been carried out in exact accordance with the ancient techniques. Just like the original, the prototype has four parts made from splitcalf leather. All parts are sewed in the sew and reverse way with delicate blanket stitches and no lining or interface has been used in order for it to be like the original. In order to maintain the original form, no joinery has been carried out in hem (edge) sewing.

5 - As for the ergonomics of the salt man footwear, it can be said that, surprisingly, not only has modern day ergonomics been applied, but also the fabricator moves a step ahead of modern science. The sole of the footwear consist of only one uniformed part which gives the user comfort and flexibility while walking or running. The line connecting the toe box and the vamp is placed above the toe joints. Therefore, while walking, not only does it not cause any problems, but it also gives more comfort to the user. In the heel, a separate part has been used which is a reminder of the heel area and supports the heel and its motion. The shank is uniformed and continues from the upper end to above the knee cap and from the lower end to the instep. No sewing line exists in this area and this gives the footwear more comfort and flexibility especially in the ankle area. The most important point about the salt man footwear is that unlike modern day boots which stand up straight, it is fabricated like stockings which do not stand up straight. This means that the footwear is shaped by the foot and not the other way around and this leads to even more comfort for the user.

In the reconstructed prototype, all ergonomic details recognized from the original have been applied. Additionally, by a comparative study of the modern ergonomic details and those of the salt man footwear, adjustments have been made.

6 - In the fabrication of salt man footwear, the shoe maker implemented the traditional leather making process and herbal tannery which, unlike modern day skin tannery, is completely based on experimental skills using resins and herbal and oil pigments. This has led to the footwear being flexible and the leather not being fragile even after 1700 years. For the purpose of sewing, threads made from sheep intestine have been used which, over the years, have been immune to decay and tear and due to the fact that the threads are greasy, the footwear sewing lines are water resistant. The sewing in the footwear is hand made with very delicate stitches all from the inside (sew and reverse). This sewing method not only makes the footwear more beautiful and elegant, but also increases the strength of the sewing lines.

7 - In the fabrication of the salt man footwear no linings or interfaces have been used and this gives the user better respiration ability while sweating and due to the fact that it is integrated with the foot, it provides better shielding against heat and cold.

Considering the results obtained from the fabrication of the modern day footwear in comparison with the salt man footwear, it is safe to claim that footwear fabrication was originated from ancient Iran and that the Iranians possess the ancient knowledge of this unique technology.

References

Foroozanfar, B. (2008). What is Ergonomics. In Journal of Industry and Safety, issue 46.

Nasiri Rad, K. (2012). Shoe Design and Modelling: Whatever a Designer must Know. Tehran: Tehran Leather University Press.

Pheasant, S. (1996). Body space: Anthropometry, Ergonomics and the Design of Work translated by Choobine, A. Islamic Azad University Tehran Central Branch.

Research Center for Conservation of Cultural Relics, (1999). Salt man: Scientific Studies Conducted on Mummies and Discovered Objects from Zanjan Collection. The first Edition,

Saffar, H. (2009). The Handbook of Shoe Sizing and Ergonomics. Tehran: Tehran Leather University Press.

Sayed Sadr, A. (2009). Encyclopedia of Iranian Hand Craft. Tehran: Farhang Moaser Publishers.

Shoe Industry Magazine (1995). The 3000-year Old Evidence of Shoe Industry in Iran.: 3(1), p. 5.